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ECTOMYCORRHIZAL FORMATION BY *PISOLITHUS TINCTORIUS*  
ON *QUERCUS GAMBELII* × *QUERCUS TURBINELLA* HYBRID  
IN AN ACIDIC SIERRA NEVADA MINESOIL

R. F. Walker<sup>1</sup>

Recent reports (Walker 1989, 1990) disclosed *Pisolithus tinctorius* (Pers.) Coker & Couch occurring in ectomycorrhizal association with Jeffrey pine (*Pinus jeffreyi* Grev. & Balf.), Sierra lodgepole pine (*P. contorta* var. *murrayana* [Grev. & Balf.] Engelm.), and California white fir (*Abies concolor* var. *lowiana* [Gord.] Lemm.) on spoils of the Leviathan Mine in Alpine County, California. This Gasteromycete, which has a near worldwide distribution in temperate, subtropical, and tropical latitudes, is a mycobiont of numerous conifer and hardwood hosts (Marx 1977). In the United States it has been most often observed in association with various pine species on harsh sites in the East, South, and Midwest (Lampky and Peterson 1963, Schramm 1966, Hile and Hennen 1969, Lampky and Lampky 1973, Marx 1975, Medve et al. 1977). Subsequently, *P. tinctorius* has been the focus of concerted efforts to develop pure culture inoculation techniques for nursery-grown pine seedlings (Marx et al. 1976, 1984, 1989a, 1989b). Outplanting trials on southern Appalachian surface mines have demonstrated the potential benefits of planting inoculated seedlings on marginal sites, which include improved survival and growth attributable to enhanced uptake of nutrients (Marx and Artman 1979) and water (Walker et al. 1989). Currently, research is concentrated on identification of potential new host species and sources of locally adapted *P. tinctorius* isolates, as well as improvement of inoculation methods. The findings reported here result from efforts to ascertain the host range of this fungus in the Sierra Nevada and Great Basin.

Leviathan Mine, an inactive, open-pit sul-

fur mine of approximately 100 ha, is located on the eastern slope of the central Sierra Nevada (38°42'30"N, 119°39'15"W) at an elevation of 2,200 m and receives an average annual precipitation of 50 cm, primarily as snowfall. A comprehensive evaluation of the chemical properties of the minesoil (Butterfield and Tueller 1980) revealed a pH of 4.0–4.5, a deficiency of plant-available N, and a potentially phytotoxic Al concentration. Efforts to revegetate the mine since its closure in 1962 have met with limited success, although more recent attempts using a variety of native and nonnative woody species have been somewhat encouraging. Additionally, the periphery of the mine has been recolonized by several species from the adjoining undisturbed forest, primarily Jeffrey and Sierra lodgepole pine and California white fir. Overall, however, much of the site is either sparsely vegetated or barren.

Further examination of Leviathan Mine spoils in September of 1989 and 1990 revealed *P. tinctorius* in ectomycorrhizal association with seedlings of the hybrid Gambel oak (*Quercus gambelii* Nutt.) × turbinella oak (*Q. turbinella* Greene). These seedlings were planted in 1987 as containerized stock grown from acorns collected in southern Nevada, the only location in the state where this hybrid occurs naturally (Tucker et al. 1961). One to three *P. tinctorius* basidiocarps, dark yellow to brown in color and matching the description of Coker and Couch (1928), were observed near solitary seedlings (Fig. 1A), while numerous basidiocarps were often interspersed among clusters of seedlings. Stipitate, substipitate, and sessile forms were encountered, varying in size from 3 to 6 cm in

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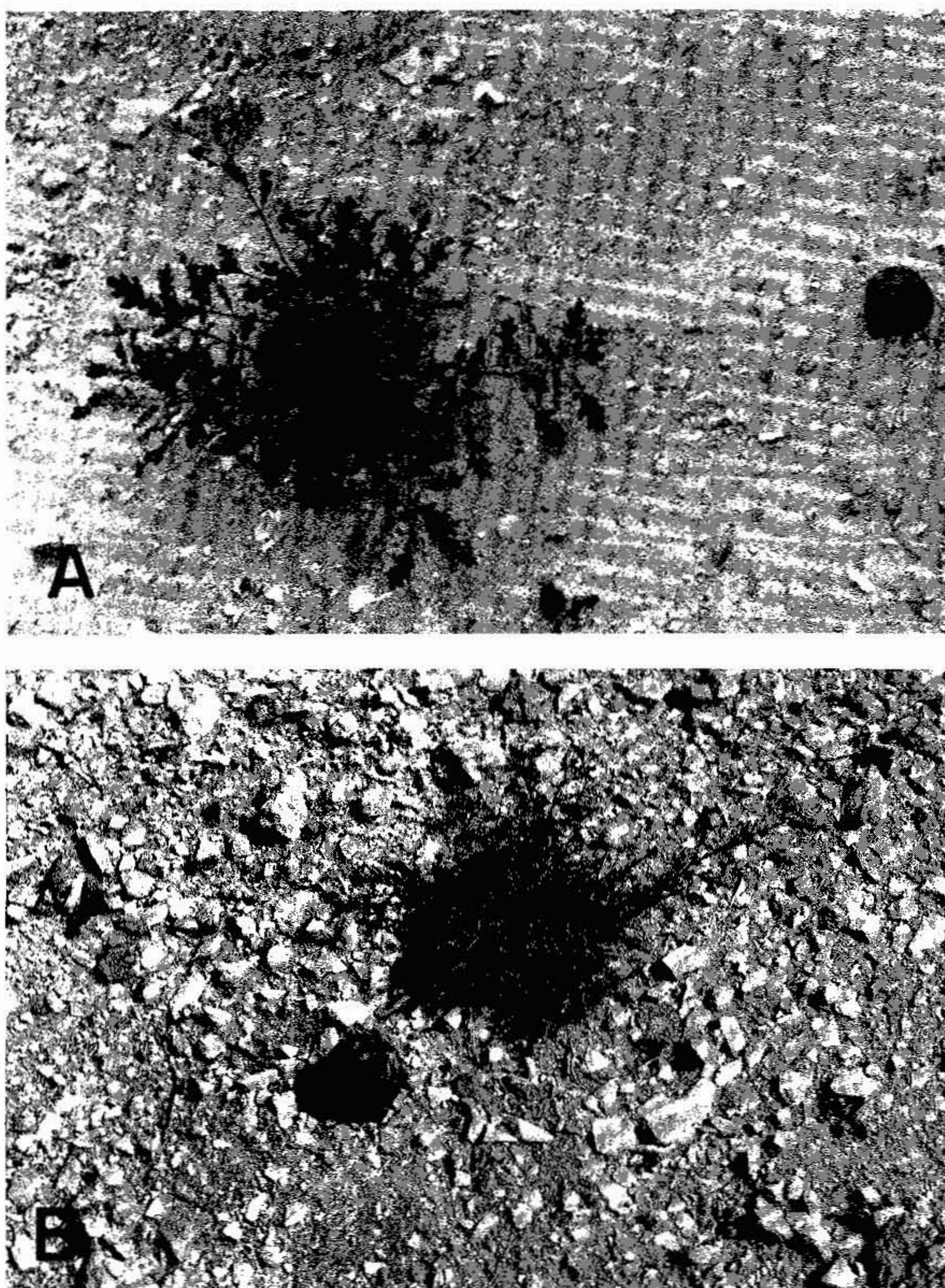


Fig. 1. *Pisolithus tinctorius* basidiocarps on spoils of the Leviathan Mine in Alpine County, California, associated with: A, Gambel oak  $\times$  turbinella oak hybrid; B, Rocky Mountain juniper.

diameter and from 8 to 15 cm in length; the basidiocarps were rarely more than one meter from the host. Mycelial strands with the characteristic gold-yellow pigmentation of *P. tinctorius* (Schramm 1966) were traced through the minesoil from basidiocarps to seedling root systems, which exhibited the similarly pigmented monopodial, bifurcate, and coral-loid ectomycorrhizae formed by this mycobiont (Marx and Bryan 1975a). Excavation of

a single representative oak root system revealed that approximately 20% of the lateral roots bore *P. tinctorius* mycorrhizae or an obvious fungal mantle.

Additional *P. tinctorius* basidiocarps were observed in the immediate vicinity of seedlings of Rocky Mountain juniper (*Juniperus scopulorum* Sarg.), Woods rose (*Rosa woodsii* Lindl. var. *ultramontana* [Wats.] Jeps.), and Siberian peashrub (*Caragana arborescens*

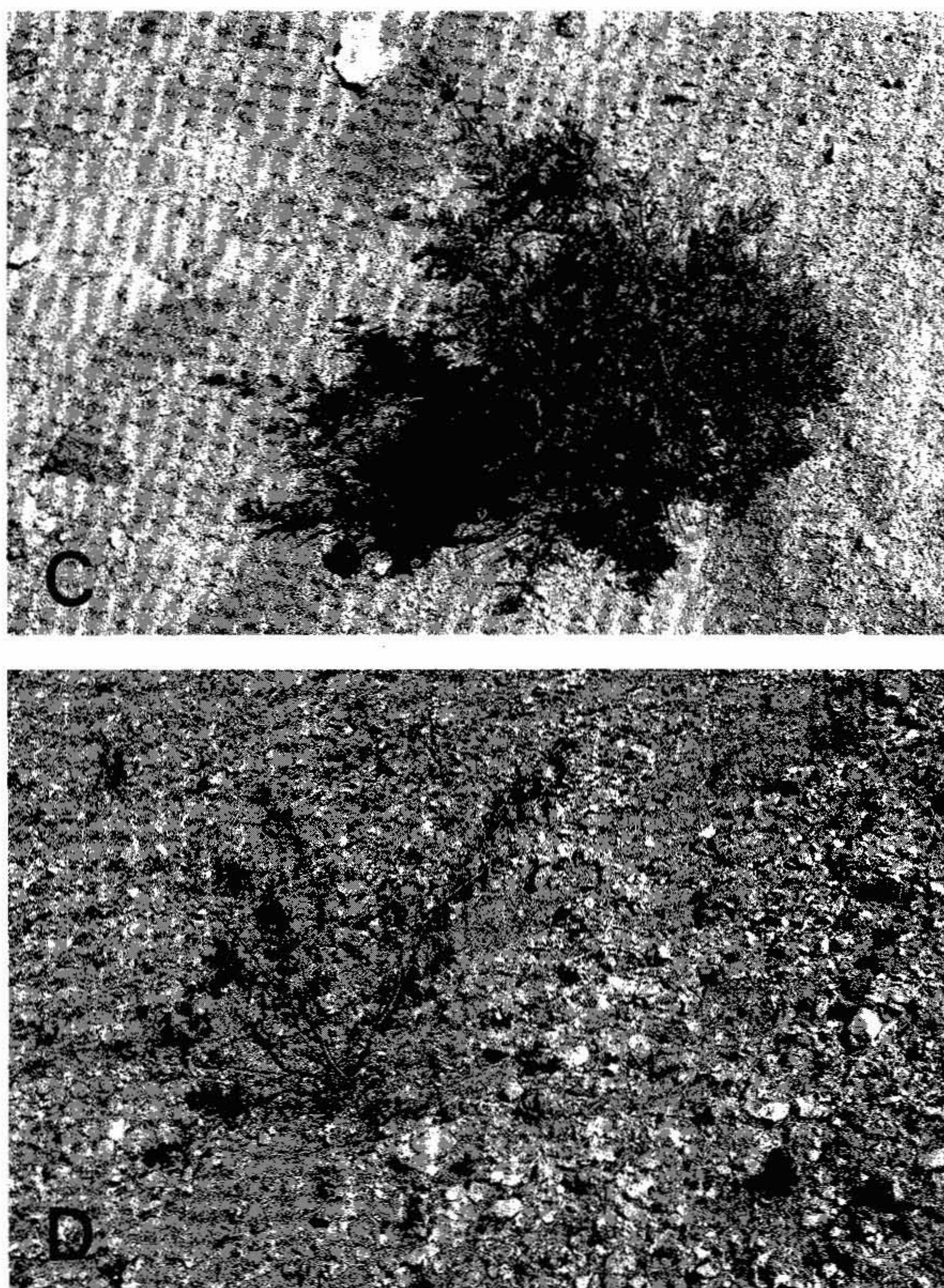


Fig. 1 continued. *Pisolithus tinctorius* basidiocarps on spoils of the Leviathan Mine in Alpine County, California, associated with: C, Woods rose; and D, Siberian peashrub.

Lam.). These three species were also planted as containerized stock with the plantings of Rocky Mountain juniper in 1984 and Woods rose and Siberian peashrub in 1986. Typically, one or two basidiocarps, similar in appearance and size to those found with the hybrid oaks, were again observed within one meter of isolated seedlings of the three species (Figs. 1B-D), and *P. tinctorius* mycelial strands were also traced through the minesoil

from the basidiocarps to the root systems. However, no ectomycorrhizae were found on any of these three species following excavation of complete root systems, although species within the genera *Juniperus* and *Rosa* are known to form ectomycorrhizal relationships (Harley and Smith 1983). Rather, on the juniper, rose, and peashrub observed here, only a loose fungal mantle of the characteristic gold-yellow *P. tinctorius* hyphae was

apparent on the fine roots. Given that excavated seedling specimens and the associated basidiocarps were  $\geq 10$  m from any other vegetation, it is likely the fungus derived its requisite carbohydrates solely from these seedlings, as most ectomycorrhizal fungi are assumed to rely on the carbohydrates obtained through the infection of an autotrophic host for completion of their life cycles and subsequent fruiting body production (Marx and Bryan 1975b). Thus, the apparent lack of ectomycorrhizal formation on the juniper, rose, and peashrub may indicate the development of a parasitic, or perhaps ectendomycorrhizal, relationship between *P. tinctorius* and these hosts in the Leviathan Mine, although there are no reports of this fungus forming either of these relationships with any of its previously identified host species.

#### ACKNOWLEDGMENTS

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